Sagebrush Burning GOOD AND BAD

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Sagebrush Burning
GOOD AND BAD

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THE SAGEBRUSH PROBLEM

THE USE OF FIRE TO REMOVE BRUSH that interferes with the production of forage and the handling of livestock on western rangelands has long been a controversial subject. It has been condemned because of the harmful, often disastrous, consequences of widespread haphazard or accidental burning. Promiscuous burning of sagebrush has played havoc on literally millions of acres of rangeland, removing the sagebrush but leaving the soil exposed to erosion by wind and water, because the burning was done in places or in a manner which discouraged the immediate reestablishment of grass and other forage cover. So much damage has been done by ill-advised burning that most of the western States and the Federal Government have imposed severe restrictions on the unauthorized use of fire.

The results of investigations described in this publication have shown, however, that, when properly used, burning to remove dense stands of sagebrush can under certain conditions be a useful tool in improving the production of forage on rangelands. Carefully planned burning, when properly carried out, is an effective means of increasing forage production. Although the guides herein outlined apply directly to the dense sagebrush-grass ranges of southeastern Idaho where the investigations were conducted, it is believed that they will be applicable, possibly with some modifications, to local conditions on other western ranges where sagebrush constitutes a grazing problem, provided the burning does not endanger other land values.

Burning is like a fine tool or intricate machine; if it is to be used with any success it must be used skillfully, and that use must follow an intelligent plan. The simple, practical rules and guides set forth here on where, when, and how to burn, and the grazing management to be used after burning, if followed carefully, will afford a reasonable chance for improvement of the range and help to avoid the damage that so frequently follows haphazard or promiscuous burning.

[1] The authors gratefully acknowledge their indebtedness to G. D. Pickford, now Supervisor, Routt National Forest, Steamboat Springs, Colo., under whose direct supervision work on this study was begun in 1932 and carried to 1936. They wish to express appreciation also to the Fremont County Woolgrowers' Association and the State of Idaho for their cooperation in conducting the work of the Fremont County burning project; to the former Bureau of Animal Industry for its cooperation on sagebrush-burning projects at the U. S. Sheep Experiment Station, Dubois, Idaho; and to the committee composed of Walt L. Dutton, former Chief of Division of Range Management, P. A. Thompson, former Chief of Division of Fire Control, W. R. Chapline, former Chief of Division of Range Research, of the Washington office of the Forest Service; C. N. Woods, former regional forester, Ogden, Utah; and Reed W. Bailey, director, Intermountain Forest and Range Experiment Station, for their technical aid in the development of the study and of this bulletin.

The stockman's justification for burning to reduce dense stands of big sagebrush lies in the difficulties and losses for which the dense sagebrush is responsible. Livestock cannot graze satisfactorily into such dense stands (fig. 1). Even when they force their way into the shrubby growth, half the palatable grasses and weeds beneath the sagebrush are likely to be unavailable to them. Ewes and lambs become separated and frequently are not reunited until nightfall. Lamb losses are increased through straying, or the lambs are caught by predators hidden in the dense growth. The stiff brush pulls wool from the fleeces. Grazing capacity is markedly reduced. Cattle graze sagebrush hardly at all and sheep graze it only lightly. Furthermore, the sagebrush deprives the more palatable perennial grasses and weeds of much of the available soil moisture.

Where usability of the range can be increased and the quantity and quality of forage improved, the stockman's need to remove the dense sagebrush stands is obvious. His use of burning, as a means to this end, has often proved effective. The difficulty is, however, that fires to reduce sagebrush are rarely planned from start to finish and are seldom properly controlled. Consequently, they may cause serious losses not only to the livestock industry but to other private and public interests. Every year such fires started on sagebrush range consume forage and expose the soil to erosion on hundreds of thousands of acres, and too often farm crops, buildings, and even farm and range animals are destroyed.

Even when these sagebrush fires are accidental, lack of appreciation of the damage they can do has often been responsible for allowing them to attain such proportions that their prompt control is extremely difficult.

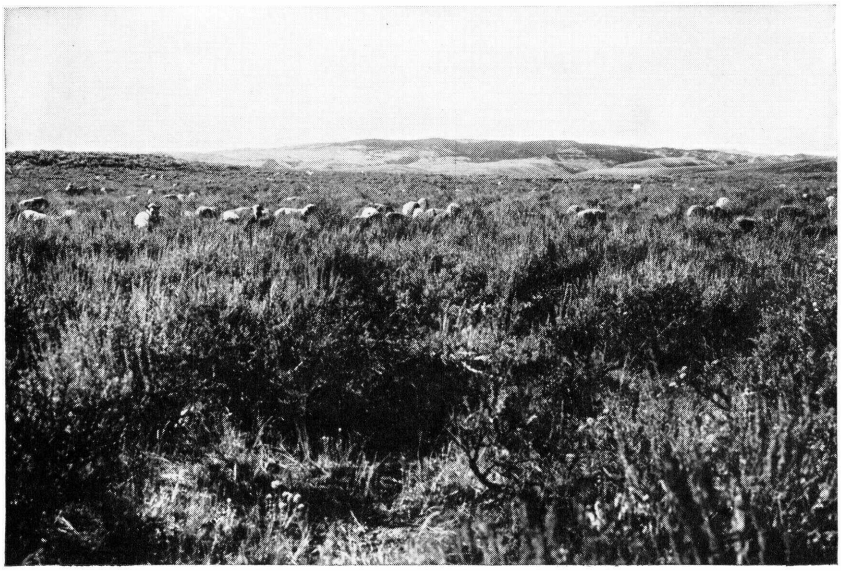

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FIGURE 1.—Dense stands of sagebrush such as these constitute a major range problem for cattlemen as well as for sheepmen. Livestock cannot graze satisfactorily into these stands. Here a band of ewes and lambs can hardly be seen in the 2-foot to 3-foot sagebrush. Burning off this sagebrush growth, if properly planned and controlled, will improve the range; but haphazard burning may prove very costly and result in serious forage losses.

Ravages of such fires, as well as of intentional fires poorly controlled, cost the public and the private interests directly concerned hundreds of thousands of dollars annually.

Property damage caused by unwise and uncontrolled fires and the annual cost of control and suppression of sagebrush fires have prompted State and Federal governments to attempt to curb the use of fire. Laws have been enacted making it a criminal offense or misdemeanor to set fires on or near lands under Federal or State jurisdiction without a permit, or to allow a fire which has been set to escape to these lands.

Often the ineffective control of the actual fire is not the worst feature of the burn. Lack of protection for the area after the burn may cause greater losses. Grazing and trailing livestock across the burned range in the succeeding fall and winter, or even the following spring, when forage supply is still scant or absent, is extremely likely to speed up soil erosion and damage the range forage irreparably.

It is clear that stockmen have a hard problem in these dense sagebrush stands, but it is equally clear that the problem cannot be solved by haphazard burning. Recognizing the need for a real solution, the Intermountain Forest and Range Experiment Station of the Forest Service, in cooperation with the Fremont County Woolgrowers' Association and the State of Idaho, undertook in 1932 a study of the effects of burning and grazing management in dense sagebrush stands on spring-fall ranges of the upper Snake River plains of southeastern Idaho. The burning experiments were repeated at two other locations on somewhat similar spring-fall range at the United States Sheep Experiment Station range in nearby Clark County, Idaho, by the Forest Service, in cooperation with the Bureau of Animal Industry. In all, approximately 8,000 acres of dense sagebrush range was experimentally burned under management. Results from other burns in the vicinity of these experimental studies have also been closely observed since 1932.

While these research findings apply directly to the upper Snake River plains, they may prove helpful in reducing dense stands of big and threetip sagebrush in other semiarid range areas of the West. Big sagebrush grows over a wide elevational and geographic range extending westward from western Nebraska to the crest of the Cascades in Oregon and Washington and into northeastern California, northward into British Columbia, and southward into northern New Mexico. Threetip sagebrush has a more restricted distribution. The findings, of course, cannot be applied to those sagebrush or other brushy species that are not readily killed by fire, nor should burning be attempted where it would endanger timber reproduction or watershed, recreational, or other land values.

The chief value of these studies is the contrast they offer between the results of the common type of burn—which can reasonably be termed "haphazard," since it is characteristically done with little provision for adequate control and no plan for livestock management after the burn—and the results of planned burning, which not only provides for a safe, effective burn with the least possible damage to existing forage, but also includes equally effective provisions for protection of the range after the burn, to permit the desirable forage plants to become reestablished before grazing is resumed.

Several methods other than burning are in use throughout the sagebrush type for reducing or eradicating stands of dense sagebrush. These include railing (dragging the sagebrush with railroad rails), shredding it with

rotary beaters, breaking it down with bulldozers, plowing with heavy disk plows, spraying with 2,4–D and other herbicides, mowing, and flooding. Each of these methods will give good results under certain conditions, and any one of them should be chosen in preference to burning when it can be used to advantage. These methods are described in United States Department of Agriculture Farmers' Bulletin 2072, Controlling Sagebrush on Rangelands.

GOOD RESULTS FOLLOW PLANNED BURNING

The sagebrush-burning experiments in Clark and Fremont Counties of southeastern Idaho show that increased usability and greater grazing capacity of the range without damage to adjacent property are dependable results of planned burning (fig. 2). This is because planned burning is a well-thought-out program of range improvement by the use of fire. It is carried out only after careful consideration of whether the area concerned may properly be burned at all and, if so, what are the proper time and manner of burning; it includes adequate control of the fire used in burning; and it invariably provides for careful grazing management after burning. Three different experimental burns were made, all on level or rolling range, 1 in 1933, 1 in 1936, and 1 in 1939. Each area had a good understory of perennial grasses and weeds before burning. Each fire was set in the late summer and was held within bounds by firelines and trained crews. Grazing or trailing by livestock was excluded from the burns for a full year; thereafter, grazing was moderate in degree and otherwise carefully regulated.

The burns made in 1933 and 1936 were in big sagebrush stands, whereas the 1939 burn was in threetip sagebrush. Careful observations were made on all three burns during the first few years, but permanent records have

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FIGURE 2.—Grazing capacity and usability of this range have been greatly increased by planned burning, including proper livestock management. Six years after the burn there is an abundance of perennial grasses and weeds, with sagebrush practically eliminated. This area is 1 mile from that shown in figure 1.

since been maintained for only the 1933 and 1936 burns. In every case, effects of burning were determined by comparisons of burned with adjacent unburned range, so that natural fluctuations caused by weather could be distinguished. Herbage production and grazing capacity of burns are therefore reported to increase or decrease as they vary in relation to unburned areas.

Within 4 years, perennial grasses and weeds on the 1933 and 1936 burns increased about 90 percent, partially replacing sagebrush (fig. 3). Although part of this increase was only temporary, after 15 years the burns were still producing 33 percent more grasses and weeds than the unburned range. Sagebrush was almost completely eradicated by burning, and after 15 years it had regained only 25 percent of its former production. Unlike sagebrush, other shrubs were able to sprout following burning and were not greatly affected.

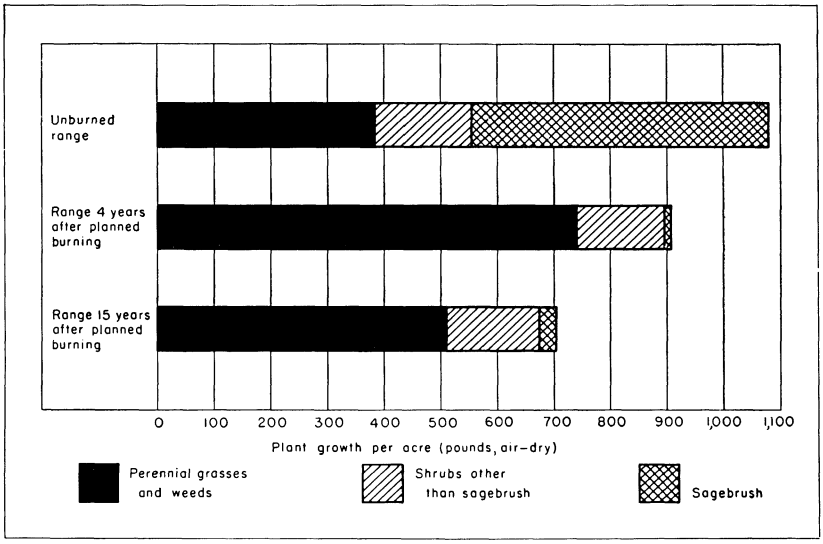

FIGURE 3.—With planned burning, sagebrush is almost completely removed, permitting an increase in perennial grasses and weeds.

These changes in vegetation caused an increase of about 85 percent in grazing capacity within 4 years after burning (fig. 4). Not all of this increase was permanent, but after 15 years grazing capacity of the burns was still 60 percent higher than that on unburned range. Although total yield of forage (plant growth which is palatable to livestock) on burned range was greater than on unburned, the chief reason for the increased grazing capacity was the change from 55 to 80 percent in availability.

On the 1939 burn, the threetip sagebrush was somewhat less dense than the big sagebrush on the two earlier experimental burns, and its removal by burning caused smaller changes. Within 3 years, however, grasses and weeds on the burn increased nearly 30 percent; and since virtually all of the forage was available, grazing capacity was 55 percent higher than on unburned range. Although detailed records were not made after this initial 3-year period, occasional inspections have indicated that much of this increased grazing capacity has been maintained.

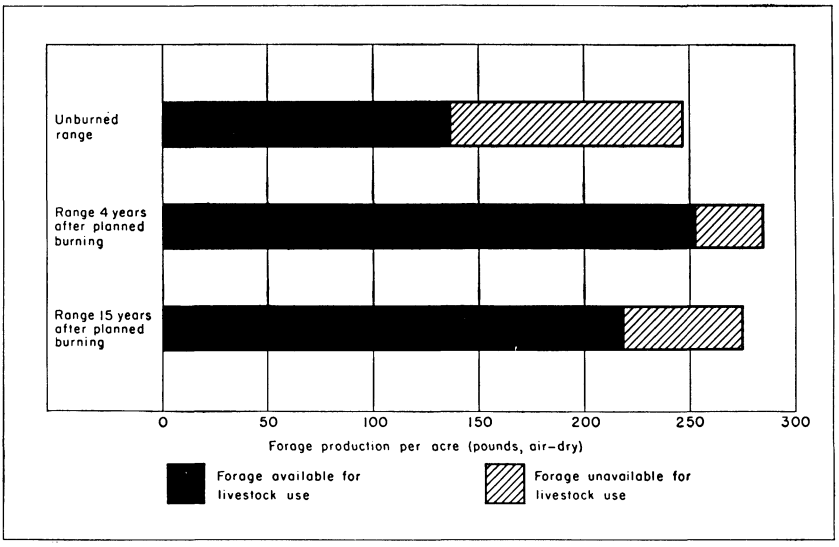

FIGURE 4.—Planned burning materially increases grazing capacity, the increase representing both greater forage production and greater availability of the forage produced.

Good results from planned sagebrush burning have also been obtained in other areas. Under different conditions in the Laramie River Valley of northwestern Colorado, the Colorado Agricultural Experiment Station obtained a 300-percent increase in grazing capacity; however, part of this increase was probably temporary. At any rate planned burning in both Idaho and Colorado removed the dense sagebrush, and the subsequent grazing management encouraged so striking an increase of the desirable perennial grasses and weeds that reseeding after burning was not necessary.

Increased grazing capacity does not come about immediately after planned burning. Usually, when the dense sagebrush (fig. 5, *A*) has been completely removed, the burned area remains free of any plant cover until the following spring, except for charred grass tufts and stubs of burned shrubs. Early in the spring perennial grasses, weeds, and shrubs begin growth from the tufts, root crowns, and rootstocks of the plants that have survived, but very few perennial seedlings come in.

This plant growth is stunted and scattered (fig. 5, *B*), unable to withstand grazing. Even so it appears more vigorous than it really is. Appearances are unreliable, since in the burned stand the growth is no longer concealed by the sagebrush and the dried residue of previous years' growth, and so seems to have increased. It is only upon careful comparison with growth on unburned areas that the true reduction in vigor is evident. Little if any seed is produced by the perennials the first year after burning. Much of the ground space may be occupied by annual weeds.

During the second spring after burning, perennial grasses and weeds stool out and take up much of the moisture formerly used by sagebrush. The fact that all species produce an abundance of flower stalks is likely to give an erroneous impression that the range is better this second year than in any following year. It is only in the third or even the fourth year after burning, however, that the perennial grasses and weeds increase sufficiently to make

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FIGURE 5.—*The immediate result of a good burn in a dense stand of big sagebrush, as shown by two views of the same plot. A,* The perennial grass and weed understory formed 30 percent of the total cover, but little of it is visible and only 40 percent of it was available for livestock use. *B,* The need for protecting the range the first spring after burning is very apparent. Perennial grasses and weeds are scattered and low in vigor; much of the soil is so unprotected that any trampling will cause it to loosen and blow away. The profit to the operator in protecting such an area from grazing is evident in figure 6.

full use of all of the moisture in the soil (fig. 6). Litter has accumulated on the ground and protection to the soil is as great as on unburned range or greater.

Usability of the range on the southeastern Idaho burns was greatly improved by the almost complete removal of the sagebrush. Big sagebrush

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FIGURE 6.—By the third or fourth year after burning, provided that grazing has been properly controlled, the perennial grass and weed stand has thickened and is making use of all the soil moisture formerly used by sagebrush. Litter accumulates on the soil surface and protection to the soil is greater than on unburned areas. This picture of the site shown in figure 5 was taken 6 years after the burn. The shrub showing conspicuously in the center and background is spineless gray horsebrush.

was completely killed and only 6 percent of the threetip sagebrush sprouted. Four, three, and two plants per 100 square feet had come in by 1942 respectively on the 1933, 1936, and 1939 burns, whereas dense stands of big sagebrush commonly consist of 30 to 40 mature plants per 100 square feet. Most of the young sagebrush plants came in during the first year or two after burning, before the grass stand thickened; since then the strong competition by grasses and weeds has greatly hindered further sagebrush seedling establishment. Thus, it appears likely that improvement in usability of the burned areas can be indefinitely prolonged by good grazing management. Occasionally, however, fairly dense stands of sagebrush seedlings become established the year following burning despite all known precautions, in which case benefits from burning may be relatively short lived.

Handling of range livestock has been greatly simplified following the burns. Sheep and cattle move about and graze without any difficulty. Ewes and lambs, on these lambing or early spring ranges, can remain close together at all times, so that ewes produce a continued flow of milk and the young lambs make better growth. Loss of lambs by straying from the flock or from predators is sharply cut. Wool losses due to brushing have been reduced if not eliminated.

Soil losses from planned burning were light, and soil movement, accelerated to some extent immediately after burning, was arrested almost completely by the end of the first spring season. Although there were slight reductions in organic matter and nitrogen of the surface soil, these were only temporary.

Range with but little understory of perennial grasses and weeds should not be burned unless it is to be reseeded the first fall following the burn. Failure to follow this procedure has been responsible for the lack of protective plant cover on many burned-over areas. When reseeding is included as a part of the burning plan, marked increases in grazing capacity and usability of the range are obtained (fig. 7). Planned burning must include reseeding the first fall following the burn. If burns are not reseeded at this time, sagebrush seedlings will probably become established, and these will seriously impede grass establishment. Stands of perennial grass established by reseeding have been very effective in preventing further soil erosion or the return of sagebrush.

But even planned burning has some undesirable effects. Such valuable plants as Idaho fescue, bitterbrush, and the partially shrubby weeds are badly damaged by fire and require a prolonged period of careful management for recovery. One-half to two-thirds of the Idaho fescue and two-thirds of the bitterbrush were killed by burning on the three experimental burns. It took 9 years for bitterbrush to regain its losses on the area burned in 1933, and Idaho fescue has not yet returned to its former abundance. This is not especially harmful on the areas studied, where Idaho fescue and bitterbrush were minor species; but were these species dominant, or others not resistant to fire, their loss would be serious.

Burning may also cause an increase in certain undesirable species. Horsebrush and rabbitbrush sprout profusely following burning and may double or triple their original herbage production. If large quantities of such fire-resistant undesirables are present, results of burning will probably be unsatisfactory.

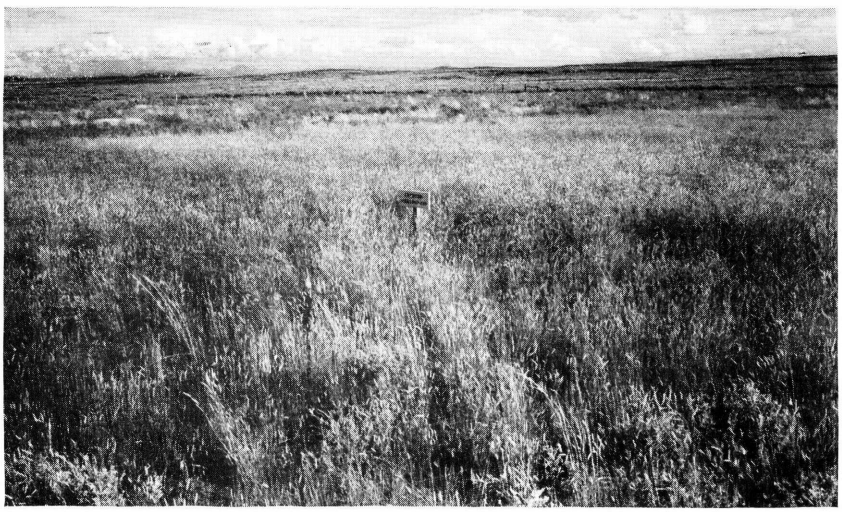

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FIGURE 7.—Reseeding after burning is necessary where there is an insufficient understory of perennial grasses before the burn. This area was burned 3 years before the picture was taken and reseeded that same fall to crested wheatgrass. It now has a grazing capacity many times that of the unburned area. What this range was like before burning is indicated in figure 9. Figure 10 shows what happens when reseeding is not employed on range where before the burn perennial grasses and weeds were insufficient or absent.

Another unfavorable result is the drying-up of the forage on burned ranges a week to 10 days earlier in the spring than on unburned ranges. If sheep, especially ewes with young lambs, are on burned ranges after this time, they will travel excessively in search of more succulent forage. Further, the value of fall forage for use during cold periods is often reduced through burning, especially if sagebrush and bitterbrush were the only two shrubs on the area before burning. Ordinarily shrubs form a substantial portion of the fall sheep ration on sagebrush ranges, especially during cold periods. When sagebrush is removed and bitterbrush badly damaged by the fire and no other browse is available, the sheep are dissatisfied and will travel widely and constantly.

From a practical standpoint, sagebrush range should never be burned over where these undesirable features, especially damage to dominant species, are not more than outweighed by the prospective increase in forage supply and decrease in difficulty of handling livestock. At least, under such conditions, planned burning should not cover the entire range in one operation, but should be applied on a part at a time. In this way the undesirable results of the burn, which would be serious if the entire range were the burning unit, will have a negligible effect in any one season.

DISASTROUS RESULTS OFTEN FOLLOW HAPHAZARD BURNING

Haphazard burning differs little from accidental burning. It is undertaken (1) without sufficient concern for the fitness of the area to be burned; (2) without any notion of whether the burn is likely to succeed or to result in loss of forage; (3) without sufficient provision for the control of the fire; and (4) without a definite program of careful grazing management after burning to insure reestablishment and maintenance of the forage cover.

In contrast to the benefits from planned burning, accidental or haphazard burning nearly always produces damage or loss, often of disastrous proportions. Without adequate provisions for control, fires set to clear sagebrush from a small tract may sweep across wide areas and destroy feed, damage the range, and destroy property. The burned area may be so extensive that it is impossible to protect it properly from too early grazing or recurrent fires. Fires may run over the range of a nearby operator who cannot make the necessary adjustments to manage grazing properly after burning. It is burning of this haphazard or promiscuous nature that is beyond doubt chiefly responsible for the fact that so many burned-over sagebrush areas have been damaged rather than improved by fire.

The individual responsible for uncontrolled fires is often faced with heavy fines or costly civil suits. For example, in Utah during 1942, a fire set by a rancher to clear sagebrush from a 640-acre area escaped and swept over more than 7,000 acres of private, State, and Federal lands in one afternoon, destroying a power-transmission line, ruining a Government installation valued at $24,000, killing over 100 deer in an experimental pasture, and causing much damage to private property (fig. 8). Individuals responsible were immediately faced with civil suits for $4,000 damage to the power lines, and several thousand dollars additional damage to property and improvements on other lands. They were further subject to trial in criminal courts for failure to get a permit or observe Federal and State fire laws.

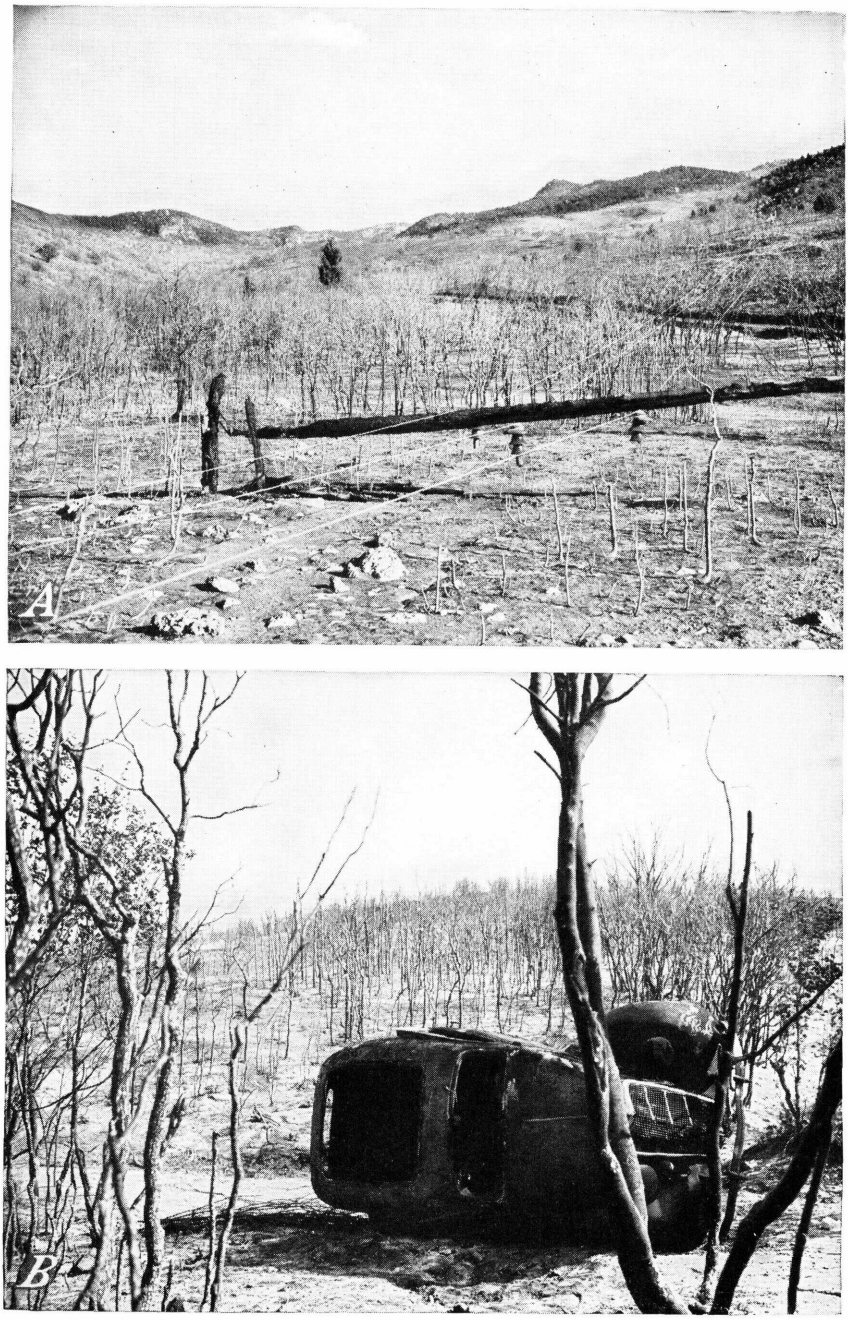

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FIGURE 8.—What happens when sagebrush fires are ineffectively controlled. A power line was badly damaged (*A*) and much personal property destroyed (*B*) by this "outlaw" burn, which also damaged the range and caused a very considerable loss of forage. The fire was set to clear sagebrush from a small area, but proper provisions for control were not made.

Soil is the basic resource upon which range productivity depends. If soil is damaged by fires or lost through subsequent erosion, range productivity is reduced for a long period. The haphazard burn that runs over steep slopes or rangeland poorly protected by understory vegetation exposes the soil to the full play of wind and water erosion. When the perennial understory before burning is sparse, the soil will be inadequately protected from erosion for a long period thereafter and serious losses are likely to occur. Soils that blow or wash easily, but have formerly been held in place by the vegetation, may begin to move when fire has removed the sagebrush or other plant cover and may not be halted for several years after burning unless they are seeded. The frequent dense clouds of dust blown from newly burned areas are themselves evidence of wind erosion, as a result of which fertile topsoil and range productivity are being lost. On steeper slopes rainfall runs rapidly from the exposed soil and carries with it the valuable surface layers. Recurrent burning intensifies these losses. Where the burn itself has not precipitated heavy soil losses, lack of provision for restricted grazing after the burn often works much havoc.

The value of forage cover is seriously reduced by the haphazard operation that disregards proper time for burning and fails to note whether the dominant perennial grasses and weeds can withstand a burn. Some forage species are destroyed by the heat of the fire itself, especially by spring and midsummer fires. Some are killed by the consequent wind and water erosion which exposes the root crowns to severe freezing during the winter or to drying winds during the late summer and fall. But by far the greatest loss is from improper aftergrazing that nearly always characterizes haphazard burning. This not only weakens further or kills many of the plants but also prevents the stand of grasses from taking advantage of the in-

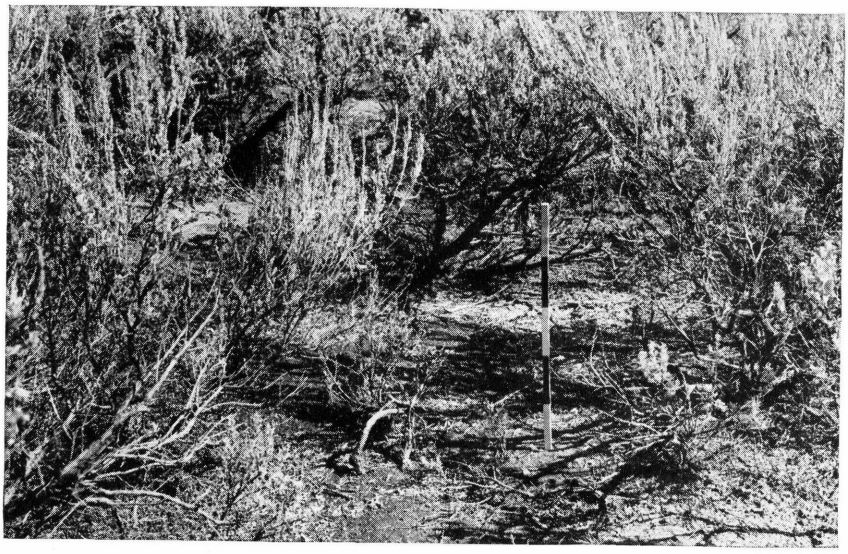

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FIGURE 9.—Sagebrush range of this sort should not be burned unless preparation is made for reseeding to perennial grasses. The absence of such grasses beneath the dense sagebrush stand is typical of much of the sagebrush-grass type. The importance of reseeding is emphasized by the contrast between figures 7 and 10, showing after effects on the same burn.

creased soil-water supplies and occupying the spaces left by removal of the sagebrush.

An even heavier stand of sagebrush returns rapidly where grasses and weeds do not offer stiff competition for soil moisture (figs. 9 and 10). Movement of livestock over the newly burned area brings the sagebrush seed in and scatters it. Soon there is a thick stand of young sagebrush plants which within 10 or 12 years will mature and once more cause a grazing problem. Burning is often resorted to again, but always with poorer prospects of improvement, unless the operation is carefully planned and carried out.

Cheatgrass brome, also known as cheatgrass, broncograss, downy brome, and downy chess, replaces perennial grasses on many areas subjected to haphazard burning. Where some cheatgrass is present, burning the range as soon as the cheatgrass is dry will destroy or so damage the desirable perennial species as to open the way to increase of cheatgrass. Improper grazing of such range after burning will also aid the cheatgrass. This replacement increases the fire hazard, because of the greater flammability of cheatgrass and the fact that it dries up a month earlier than do the perennial grasses. Recurrent burning from accidental or other fires, coupled with improper grazing, accelerates the replacement, until pure cheatgrass stands are brought about. With this change the grazing value of the forage cover is decreased, because of the short season during which cheatgrass stays green and because of its wide fluctuation from year to year in volume of forage produced.

Once a dense stand of cheatgrass is brought about, range improvement by reseeding or grazing management is extremely difficult. Also the number and seriousness of accidental range fires is increased, since cheatgrass fires

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FIGURE 10.—If perennial grasses and weeds provide no competition, the sagebrush will return almost immediately. Fire is not magic—it will not make grass. This view was taken at the same time as that in figure 7 and shows what is to be expected on such an area if it is not reseeded.

easily gain sufficient volume to travel over and damage other types of cover that normally are not very flammable.

Even where cheatgrass is not a factor, recurrent burning may be harmful because it permits excessive increases in the undesirable sprouting shrubs, horsebrush and rabbitbrush. Furthermore, it would probably result in eventual extinction of the fine bunchgrasses and bitterbrush. Even though a single planned burn causes only slight erosion and a temporary reduction in organic matter and nitrogen, it is also quite possible that recurrent burning would result in soil impoverishment.

Cost of putting out uncontrolled or accidental fires and of protecting against them is excessive, yet they must be checked to protect adjacent range and property. Further, it is notable that in localities where haphazard burning is habitual, the public is generally indifferent to the dangers and damage of accidental fires. This indifference in turn produces carelessness in preventing fires along highways or near campgrounds and failure to check such accidental fires while they are still small, or to report them to the proper authorities. Haphazard burning itself and the increased number of accidental fires for which it is directly or indirectly responsible make it necessary for fire protection agencies to maintain a larger organization for the control of fires and to spend much more money on suppression for a much longer period than might otherwise be necessary.

Improper Grazing the Worst Feature

Improper grazing practice after burning is more frequently responsible for soil loss and damage to the plant cover than any other feature of haphazard burning. The character of the injury inflicted is clearly illustrated by a comparison of the results on 2 Clark County burns—1 the 1936 experimental burn at the United States Sheep Experiment Station and the other a range near Camas Creek which was haphazardly burned in 1933. Both areas were burned at about the same time of year, had an excellent understory of grasses and weeds before burning, and were of level or rolling topography. The essential difference between the two burns was in the manner of burning and the grazing management afterwards. On the experimental area the fire was carefully controlled, and the range was protected from grazing and trailing for a full year after burning. Since that time it has been grazed conservatively. On the other hand, the Camas Creek tract was allowed to burn uncontrolled and without plan or preparation for proper grazing after burning. The uncontrolled fire swept on through and 2 miles past the intended limit. Sheep and cattle trailed across the range immediately after burning and it has been heavily grazed ever since.

Grazing capacity of the experimental burn after 12 years was approximately double that of the adjacent unburned range, in contrast to only a 4-percent increase at Camas Creek 9 years after burning. Much of this difference was due to a 53-percent increase in perennial grasses on the experimental burn as compared with a decrease of 23 percent on the other (fig. 11). Furthermore, this decrease in grasses was accompanied by the immediate return of sagebrush in such abundance that, within 9 years 50 percent more sagebrush plants (fig. 12) occupied the burned lands than are found in comparable dense unburned stands. This plentiful stand of sagebrush plants, even though young, produced more herbage than did the unburned range (fig. 13). Grazing capacity here would have been even less had it not been

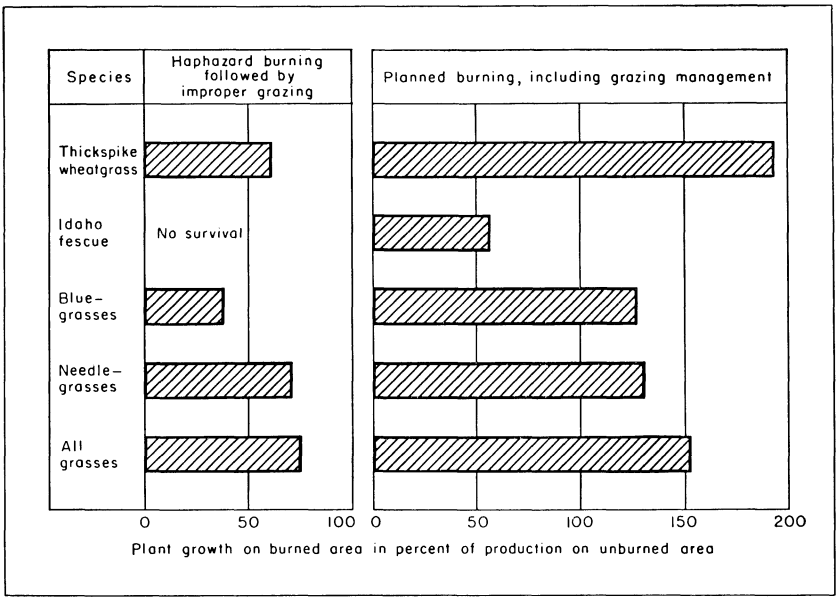

FIGURE 11.—The improper grazing of burned range destroys much of the desirable grasses unharmed by the fire, and further accentuates the damage to the species that are not fire-resistant.

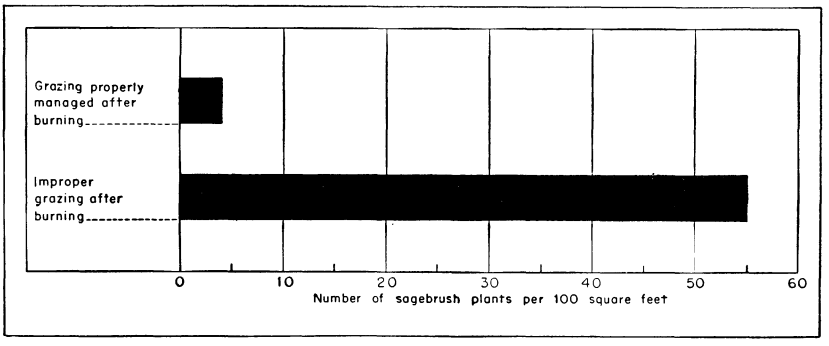

FIGURE 12.—Improper grazing management after burning is often responsible for the very abundant return of sagebrush. A dense stand of sagebrush is considered to be 30 plants per 100 square feet.

for the large amount of relatively low-value forage furnished by the sagebrush. Thus, improper grazing after burning on the Camas Creek area seems accountable not only for the failure of the burned area to make substantial increase in grazing capacity but also for a decrease in the quality of the forage produced.

On the Sheep Station area all perennial grasses but Idaho fescue increased in production. In contrast, the only increase on the Camas Creek area was in Douglas sedge, which is included with "all grasses" in figure 11. Even thickspike wheatgrass, a very fire-resistant species spreading rapidly by rootstocks, was reduced 39 percent by improper grazing, as compared

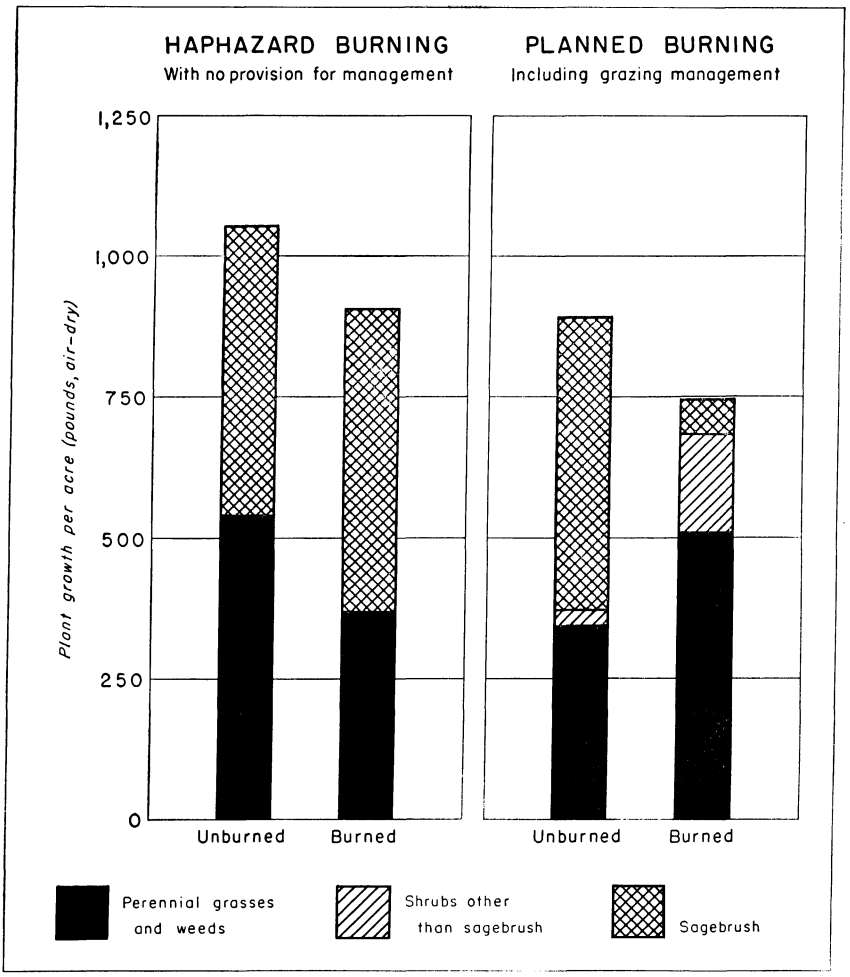

FIGURE 13.—Plant growth of different classes of vegetation under planned and haphazard burning and grazing. Proper grazing management after the burn prevents the return of the sagebrush and greatly promotes increase in the stand of perennial grasses and weeds. The fact that no provision for proper grazing is made in haphazard burning is one of the chief reasons why sagebrush so often returns in considerable quantities and perennial grasses and weeds are reduced.

with a 93-percent increase under good grazing management. Idaho fescue, normally not very fire-resistant, with a 56-percent survival under planned burning was completely killed out by haphazard burning. Bluegrasses, among the most palatable grasses on the spring-fall range of southeastern Idaho, were reduced 62 percent by the haphazard practice, but increased 27 percent following the planned burning.

Furthermore, soil losses and damage to soil fertility, only very slight under good grazing management, were serious at Camas Creek. These were due mainly to trailing and grazing the first year, which, together

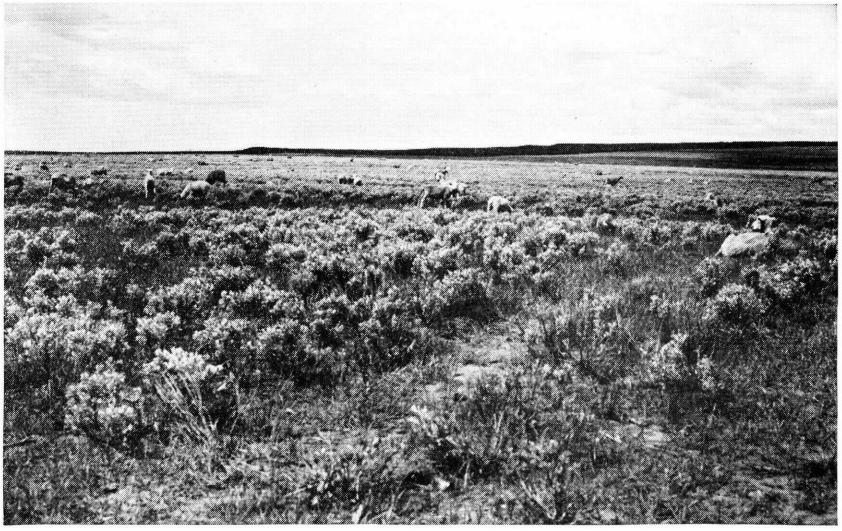

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FIGURE 14.—Five years after a haphazard burn, characterized by no effort to adapt grazing practice to the needs of the range, the sagebrush has returned in considerable quantity and in another 8 or 10 years will form a stand so dense as to be very objectionable. Originally the stand of perennial grasses was heavier than that on the area shown in figure 1. The contrast between this view and that in figure 2 speaks for itself.

with severe grazing during later years, prevented any thickening of the herbaceous plant cover.

Thus, the problem of dense sagebrush is at best only temporarily relieved when burning is followed by improper grazing practices (fig. 14). Soil is less fertile, desirable perennial grasses and weeds are less abundant, and in some cases the less desirable annual grasses have increased. Within 10 to 15 years after burning, the sagebrush will once again form a dense stand and must again be eliminated. But the reduced understory of perennials and the less fertile soil will make any promise of range improvement much less certain than when the area was first burned.

ESSENTIAL CONSIDERATIONS IN PLANNED BURNING

The widely different results from proper and improper burning, and the care required to insure permanent good results, make effective planning absolutely necessary if burning is to produce the benefits desired. Burning is like a fine tool or intricate machine, it must be used skillfully and in compliance with an intelligent plan, if good results are to be secured.

The considerations that distinguish planned from haphazard burning fall into four groups—where to burn, when to burn, how to burn, and how to manage the area after burning. The guide setting forth the various requirements for planned burning can be applied only after careful study of each individual area and the program for burning must then be formulated on the basis of the needs of that area.

Where To Burn

Burn sagebrush range only where all of the following conditions prevail:

1. Where fires can be and will be controlled.
2. Where principal use of the area is for livestock grazing.
3. Where soils are fairly firm and slopes less than 30 percent.
4. Where big and threetip sagebrush are dense and form more than a third of the plant cover.
5. Where fire-resistant perennial grasses and weeds form more than 20 percent of the plant cover; or if they form less than 20 percent, reseeding to perennial grasses is practicable.
6. Where proper grazing practices can be and will be used after burning.

But:

1. NOT where the principal use of the area is for watershed, timber production, or important values other than grazing.
2. NOT where soils are highly susceptible to wind or water erosion.
3. NOT where important grasses, weeds, and browse are seriously damaged by fire.
4. NOT where more than half the understory is cheatgrass brome, unless the area can be protected from accidental fires.
5. NOT where there is an abundance of such sprouting shrubs as horsebrush and rabbitbrush.

Burn only where fires can be controlled.—The fire must be held to the area that it is intended to burn, if costly damage to other ranges and destruction of property are to be avoided. Only where fire has been so controlled can adequate provisions be made for protection from grazing after burning. Burning should never be attempted where it is economically impossible to construct satisfactory firelines, or where the manpower necessary to assure control of the fire is not available. Cost of setting a fire may be negligible, but the cost of an uncontrolled fire may be exorbitant, as in the case of the Utah fire already mentioned.

Experience with the use of fire is a very important feature of control. Accordingly, it will usually be advisable the first year to burn an area small enough so that the difficulties of control can be thoroughly studied without endangering other land. Such a small preliminary burn will also show the possibilities in the use of fire under local conditions.

Burn only where principal use of the range is for livestock grazing.—In such situations, the increased grazing capacity and usability of the range as the result of careful burning will ordinarily outweigh the damage to lesser values. On the other hand, such gains on important watersheds may be more than offset by the loss of soil, damage to reservoirs, or flooding of croplands; on timber-producing lands, by the destruction of timber reproduction or mature trees; or on winter range for big game, by destruction of browse forage and resultant starvation of wildlife.

Burn only where soils are firm and slopes gentle.—Fairly firm soils on areas of level or rolling topography are not likely to be damaged by erosion following removal of the plant cover if a good perennial grass stand will clothe them the next spring. But where soils are likely to wash or blow, or where slopes are over 30 percent, danger from erosion is high and exposure of the soil may be disastrous. Burning seriously magnifies the danger from erosion by completely removing protection from the soil for the remainder of the summer, that fall, and the first part of the following

spring. In many instances so much of the topsoil layer may wash or blow away that the roots of perennial grasses will be exposed and a good protective cover will be slow to become reestablished.

Burn only where sagebrush is dense.—Where sagebrush forms less than a third of the plant cover, it seldom interferes seriously with the handling of range livestock, and is even of value as sheep browse in the fall and for the protection it affords in cold periods in that season. Furthermore, where stands are not dense, the benefits to be expected from sagebrush removal are much less than in heavy stands. Removal makes available an amount of soil moisture roughly proportional to the density of the sagebrush. The increase in surviving species is limited by the amount of this moisture. Thus, in scattered stands of sagebrush, the degree of improvement to be expected from burning is not large enough to warrant the use of such a dangerous tool, its cost, or the year's loss in range use that is entailed. Also, unless the grass understory is thick, sparse stands of sagebrush provide a scanty supply of fuel and cannot be burned except under extremely hazardous conditions.

Burn only where fire-resistant perennial grasses and weeds are abundant.—A stand of perennial grasses and weeds forming at least 20 percent of the plant cover is necessary if their spread after burning is to be rapid enough to prevent serious soil erosion and the early return of sagebrush. But it is essential that these grasses be largely of fire-resistant species. A heavy stand coming in after burning will stop soil loss by the first spring, whereas a light stand will permit erosion to continue for a year or two. Sagebrush seedlings, also, will have difficulty in surviving if all vacant spaces are filled and soil moisture is being used by perennial grasses and weeds. But to the degree that soil moisture is not utilized by the grasses and weeds, because of their sparseness, sagebrush seedlings will reinvade the unoccupied spaces and become firmly established. The longer excess soil moisture remains available, the greater the chance for return of sagebrush. The larger the amount of moisture unused by the other vegetation, the greater the number of sagebrush plants likely to become established.

Sagebrush burning does not affect all plants the same way—some it injures seriously, some slightly, and some not at all. This varied effect is indicated in the following list of common plant species of the sagebrush-grass type of the upper Snake River plains, the condition of species at the end of the first growing season after burning being taken as the basis of classification. Names in italics indicate species that are important because of their abundance or because of their moderate or high palatability. Those undamaged species marked with an asterisk spread by rootstock or root shoots.

Species Severely Damaged

Idaho fescue
Threadleaf sedge
Low pussytoes
Littleleaf pussytoes
Uinta sandwort
Hairy fleabane
Wyeth eriogonum
Mat eriogonum
Hoary phlox
Saskatoon serviceberry
Big sagebrush
Threetip sagebrush
Granite gilia
Broom snakeweed
Antelope bitterbrush

Species Slightly Damaged

Bluebunch wheatgrass
Prairie junegrass
Indian ricegrass
Sandberg bluegrass
Nevada bluegrass
Subalpine needlegrass
Needle-and-thread
Astragalus
Northwestern paintedcup
Tapertip hawksbeard
Sticky geranium
Tailcup lupine
Matroot penstemon
Munro globemallow

Species Undamaged

Crested wheatgrass
**Thickspike wheatgrass*
Cheatgrass brome
*Plains reedgrass
**Douglas sedge*
*Western yarrow
Wild onion
Arrowleaf balsamroot
**Purpledaisy fleabane*
Velvet lupine
**Longleaf phlox*
*Flaxleaf plainsmustard
*Lambstongue groundsel
Foothill deathcamas
Downy rabbitbrush
Spineless gray horsebrush
*Orange arnica
*Common comandra
*Mountain snowberry

In judging the adequacy of the perennial grass and weed understory it must be recognized that nonresistant plant species such as Idaho fescue, threadleaf sedge, the partially shrubby weeds, and bitterbrush may require years of careful grazing management to recover former abundance. Where these species form the major portion of the understory, burning may result in excessive soil erosion, early return of sagebrush after burning, and, in addition, the loss of these valuable species from the cover. These species should not be counted toward the 20 percent minimum limit, and other methods of removing sagebrush must be used on such lands. Large areas having dominant perennial grass and weed species not known to be resistant to fire should not be burned without preliminary tests on smaller areas to indicate whether the questionable species are fire resistant.

Rapidity of increase by the lightly damaged or the uninjured species depends roughly upon whether they do or do not spread by rootstocks. Those that do not, even though undamaged, increase slowly after burning. These include several of the more palatable species, such as bluegrasses, needlegrasses, junegrass, Indian ricegrass, arrowleaf balsamroot, and tailcup lupine. Despite a ready recovery from burning and rapid increase in vigor, any increase in number of plants must wait production of seed. This seldom occurs in any abundance until the second year after burning.

Plant species spreading by rootstocks or root shoots (marked with an asterisk in the list above) are least harmed and spread most rapidly after burning. Their underground stems and roots are unharmed and are ready for immediate increase. Such species as thickspike wheatgrass, Douglas sedge, western yarrow, longleaf phlox, and purpledaisy fleabane will double in production within a 3- or 4-year period. They are, however, secondary in palatability. Their marked increase often hides the partial disappearance of more valuable species and may be largely responsible for an appearance of greater increase in grazing capacity than actually occurs. It is important that this be recognized in judging range improvement after burning.

Wherever less than one-tenth of the ground is covered by vegetation, less than 600 pounds of herbage (air-dry weight) per acre is produced, the annual precipitation is less than 9 inches, or there is moderate or greater

likelihood of soil washing or blowing, it is imperative that fire-resistant perennial grasses and weeds make up more than 20 percent of the plant cover; else, after burning, the plant cover may not be thick enough to prevent serious soil losses. Where the erosion hazard is moderate or greater, immediate revegetation is essential to prevent exposure of the soil for longer than the fall, winter, and spring immediately after burning. If vegetation is light on such areas, sagebrush should not be burned, even though provision can be made for reseeding.

Burn areas deficient in fire-resistant perennials only when reseeding is practicable. Information on where reseeding is likely to succeed, what species to use, and how to plant can be secured from several State and Federal publications or from local men who are experienced in grazing management and reseeding work. Where reseeding is not likely to succeed or where it is not practicable, areas having less than the minimum limit of perennial grasses and weeds should not be burned.

Where cheatgrass brome is dominant in the understory, full protection against recurrent fires must be assured.—Cheatgrass is an annual and a very prolific seeder. Its seed is seldom damaged by sagebrush fires. The year following fire, cheatgrass is likely to take over all the available space before the perennial grasses and weeds recover sufficiently from burning to occupy it. Once established, cheatgrass will retard increase in perennial grasses and weeds. Although the perennials, if not further retarded, will eventually overcome the competition, the handicap of injury by midsummer fires or overgrazing will so hold them back that cheatgrass will further replace them. Thus, if dense sagebrush is burned from areas that have heavy stands of cheatgrass, it is essential to provide special protection against accidental fires in addition to the good grazing management given any planned burn.

Burn sagebrush only where grazing management is planned and provided for.—Where planned grazing practices are not practical, or are not employed, burning the range can result only in short-lived increase in grazing capacity and will almost certainly be expensive in terms of lost range productivity.

When To Burn

Burn Sagebrush Range:

1. In the late summer or early fall.
2. Not earlier than 10 days after perennial grass seed is ripe and scattered and leaves are nearly dry.

But:

1. NOT in midsummer.
2. NOT as soon as cheatgrass is dry.
3. NOT in a drought year.

Wait till 10 days after seed of perennial grasses is ripe and scattered.—Other indicators of this date of readiness are that Sandberg bluegrass has been completely dry for nearly a month, spineless gray horsebrush seed is ripe, downy rabbitbrush has just finished blooming, and big and threetip sagebrush are just about to begin blooming.

The need for burning at this time, and not before, is illustrated by figure 15, showing the relative effects of burning at different dates on the production and vigor of bluebunch wheatgrass the following year.

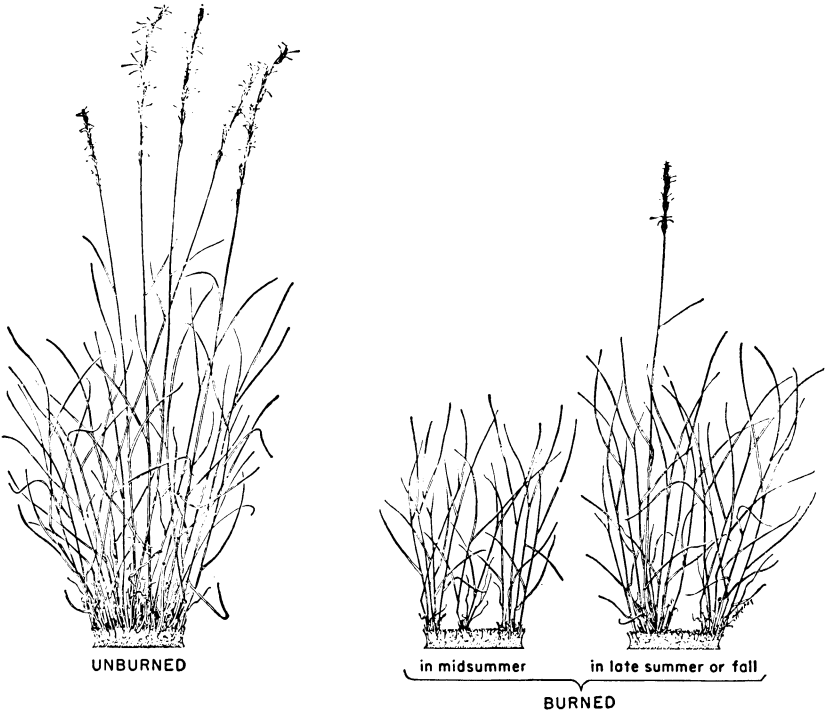

FIGURE 15.—Effect on clumps of bluebunch wheatgrass of burning the previous year—in midsummer and in the late summer or early fall—as compared with no burning.

Midsummer drying of cheatgrass is not a signal for burning.—On ranges with an abundance of cheatgrass the liklihood of too-early burning is great, since this common annual grass dries 4 to 6 weeks before associated perennial grasses and weeds (fig. 16). Fires will burn readily 2 or 3 weeks be-

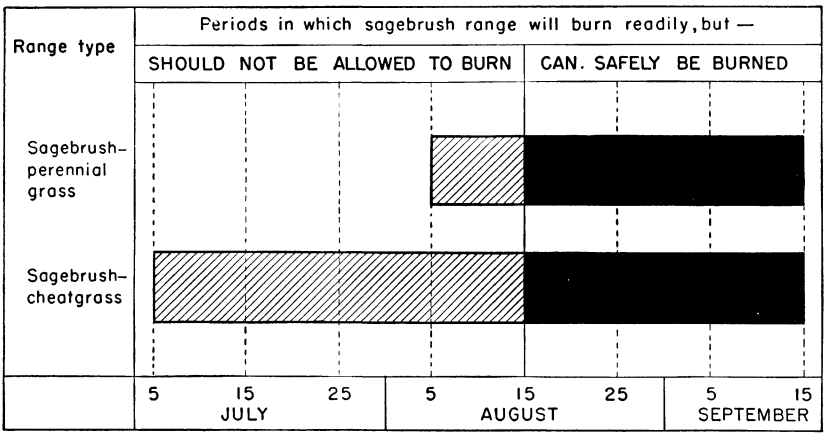

FIGURE 16.—Summer and fall periods during which sagebrush range on the upper Snake River plains will burn, when it should be burned, and when it should not be burned.

fore seed of the perennial species ripens and herbage begins to dry. Perennial grasses burned in the period from shortly before their seed is ripe until the seed is disseminating will be seriously injured and will produce in the following year less than one-third the forage produced on unburned plants. Clumps will be badly split up, and leaves will be reduced in length. Furthermore, midsummer burning increases the chances for serious soil loss by wind and water erosion. The period of soil exposure to possible terrential summer storms and high winds is lengthened, since these are most likely to occur during July and the first part of August.

Early summer burning as soon as cheatgrass has dried enough to burn, however, is an effective method of reducing the cheatgrass stand the following year. If the perennial grass understory is so thin that artificial seeding will be necessary after burning, damage to desirable species is inconsequential and the advantage of the reduced cheatgrass competition will undoubtedly outweigh the harmful effects of the early burn.

Burn in late summer or early fall.—If the burn comes after seed is disseminated and when leaves are drying rapidly, reduction in vigor of grasses will be held to 30 to 40 percent the following year; some splitting up of clumps will occur, leaves will be somewhat shorter than on unburned plants, and fewer flower stalks will be produced. While this amount of damage may appear great, under proper grazing practice the valuable perennials will recover and by the second year may be producing even more than before.

Time burning by plant growth.—It is important that proper dates for burning be determined from the plant growth each year, rather than by any set calendar date. On most of the upper Snake River plains bluebunch wheatgrass seed is not usually disseminated nor do the leaves begin to dry rapidly until after August 10. But elevation or other causes may advance or retard the maturity of palatable and otherwise desirable plants, and the date of burning must be adjusted accordingly. At the slightly higher elevations on the upper Snake River plains adjacent to national forests there is frequently only a short period during the latter part of August when sagebrush will burn satisfactorily and when it should be burned.

Burning should not be done in a drought year.—All range forage is needed in a drought year because of lowered production. Plants already weakened by the impact of the drought are likely to be killed out partially or wholly by added injury from burning. Furthermore, fire is difficult to control in a drought year, when all vegetation is tinder-dry, winds are of high velocity, temperatures high, and humidities low. These characteristics are all conducive to extremely hot fires.

How To Burn

Burn only after:

1. All local and Federal fire laws have been carefully studied and a burning permit has been obtained.
2. A program for burning has been prepared.
3. Adequate firelines have been constructed around the area.

Then:

1. Select carefully the day for burning so that there is certainty of a good burn but little chance that the fire will get out of control.

2. Have plenty of well-trained men, equipment, and supplies on hand before the fire is started.
3. Start the fire late in the day.

But:

1. DO NOT burn without a permit.
2. DO NOT burn where adequate control of the fire cannot be assured.
3. DO NOT burn without adequate control lines, men and equipment.,
4. DO NOT burn when high winds are blowing or impending.
5. DO NOT leave fires burning—be sure every fire is put OUT.

Be properly informed.—Get from the local fire warden, State forester, or nearest employee of the Forest Service or Bureau of Land Management full information on local and Federal fire laws. Federal statutes state that it is a criminal offense for anyone to set on fire or cause to be set on fire any timber, underbrush, or grass or other flammable material upon the public domain or other lands owned and leased by the United States, or to set fires near such lands, without the permission of the United States. In addition nearly all Western States have fire laws governing the use of fire within the State, requiring permits to burn during certain seasons of the year, and setting up requirements for the "safe" use of fire. Get a permit to burn from the local fire warden and, if county, State, or Federal land is involved, additional permission from the agency under whose jurisdiction the land falls. Lack of knowledge is no excuse for failure to comply with the law and will not save the violator from heavy fines, nor prevent civil suits being brought against him for damages his fires may cause to the property of others.

Prepare a program for burning, in which all phases of fire control, burning, and grazing management have been considered. It is essential to determine before any further steps are taken precisely the equipment needed for fire-line construction, the men for fire control, the seed and equipment for reseeding if that is necessary, and the additional range or feed supplies to permit protection of the burned areas for a year. Then make sure that all these essentials are available.

The burning program must be adjusted to the availability of additional range feed to care for the livestock during the period of nongrazing, since this may limit the area of range that can be burned in any one year. A program of rotation burning may be advantageous. Such a program, illustrated by figure 17, provides for the burning each year of not more than one-quarter of the land planned for improvement. Rotation burning minimizes the area of supplementary range to be leased and the quantity of feed to be purchased. Rotation burning will not be advantageous if immediate improvement of the entire area is essential or if enough additional forage to permit a year's protection, or fences for the needed distribution of cattle, cannot be obtained. Burning the entire area at one time is more economical in actual burning costs and lessens the liability of livestock trailing over the edges of newly burned areas and other chances for the return of sagebrush.

Construct adequate firelines around the area.—Burning can be done successfully only when there is relatively high fire danger, hence the fire that escapes from control is almost sure to be serious and dangerous. Careful preparations must be made to confine fire within firelines, and these must be adequate to stop the fire under the most hazardous conditions.

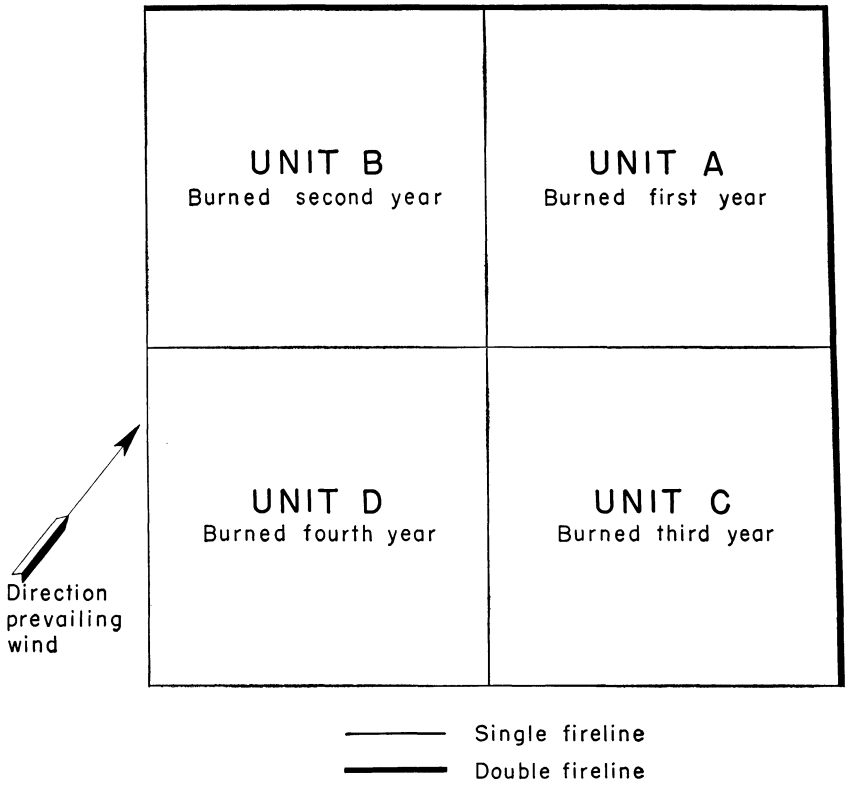

FIGURE 17.—Diagram of a 4-year rotation burning schedule showing location of firelines. Graded lines around Units A and B should be constructed the 1st year and around Units C and D the 3d year.

On ordinary sagebrush-perennial grass range, a double fireline 100 to 200 feet wide, extending along the leeward side (the side toward which the wind commonly blows in the afternoon) is necessary. On the other sides, a single cleared line or roadway 6 to 8 feet wide is sufficient to prevent the fire from working backward against the wind. This precaution is especially important on cheatgrass and other ranges of unusual flammability.

With rotation burning, location of firelines takes advantage of the fact that fires rarely travel over 1-year-old burns and are easily arrested with the aid of a single line on 2-year-old burns. The rotation burning illustrated in figure 17 is planned for an area subject to a southwest wind. Some maintenance may be required on cleared lines constructed the previous year, but in the interest of economy as much line as possible should be constructed when equipment is on the ground. These lines may often be used then and afterwards as roads for driving livestock and hauling water and supplies.

Mechanical work on the cleared lines can be carried out in the summer, well ahead of the season for burning. Caterpillar tractor and bulldozer, caterpillar tractor and power grader, and a road patrol have been used in

constructing firelines at the United States Sheep Experiment Station. The "cat"-grader combination was the most satisfactory on rocky areas, but the road patrol performed well where the soil was fairly free of rocks. Well-traveled roads, if they are entirely free of vegetation and of sufficient width, may be used for firelines.

Preparation of the double fireline consists of clearing 2 parallel strips (the 1 nearer the area to be burned 6 to 8 feet wide and the other about 12 feet) separated by a 100- to 200-foot uncleared strip. Normally two swaths of the blade will be necessary to clear the wide line, and each of these will provide a ridge of debris (fig. 18) which will help to prevent drift of sparks across the line at the time of backfiring and burning the main area. It is important that these ridges be thrown towards the area to be burned so that any sparks smoldering in this debris will be on the inside of a cleared line. All cleared strips should be scraped free of plant cover—sagebrush, grass, or litter—to the mineral soil.

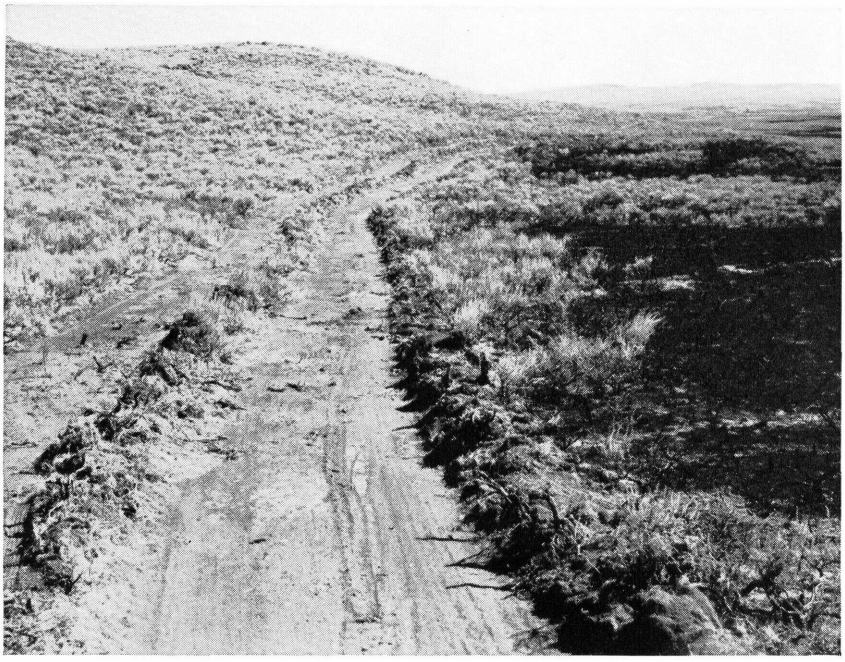

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FIGURE 18.—A part of a double fireline showing the wide, cleared line and part of the uncleared strip that has been burned out by backfiring. The right side of the backfired area (not shown) is bordered by a narrow, cleared line made by only one swath of the grader or patrol blade.

Prior to the main burn, the uncleared strip between the two lines must be burned out by progressive backfiring against the wind from the outside to the inside line. Backfiring is the most critical part of the entire burning operation, and all possible precautions should be taken. In areas of heavy brush and grass, a 4- to 6-foot strip should be burned out before setting fires back to any greater depth. Several men should be used in backfiring—for each man setting fires, at least three should be available to prevent escape of the fire. Any fires jumping across the cleared line should be

extinguished immediately; soil thrown forcefully at the fire, by use of a long-handled round-point shovel, is very effective. Backfiring should be done only in the forenoon when normally wind velocity is lower and humidity is higher than in the afternoon. If all these conditions are met, there is but little chance of the backfire escaping, especially if the work is done as soon as perennial grasses are dry enough to burn. This will provide assurance of fire-control lines being well established when the proper time for burning arrives.

After firelines have been constructed, it is advisable to have them inspected by someone experienced enough to detect weak spots where fires might sweep across. When firelines are adequate and perennial grasses have reached the proper stage of development, preparations for burning are complete.

Select a hot, dry day with a steady, moderate wind.—Fairly fast crown fires are needed in sagebrush burning, lest the fire split and go around thin stands of sagebrush on shallow rocky areas or rock outcrops and leave the leeward sagebrush unburned. To produce the type of fire needed, temperatures must be high, humidities low, and wind of a moderate velocity and from a prevailing direction. Cloudy days, when changeable wind direction may cause patchy burns or sweep the fire out of control, and days when the wind is blowing so hard as to cause undue danger of the fire getting out of hand, must be avoided. The United States Weather Bureau should be called upon for a forecast of the possibility of unusual wind or other weather conditions that might affect burning.

Have plenty of well-trained men, equipment, and supplies on hand.—Weed or pricklypear burners for setting fire to the area, ordinary round-point shovels, water and water containers, and, if available, backpack fire pumps, as well as a first-aid kit, must be ready when the proper day for burning comes. Sufficient men should be on hand (15 or 20 men for a 1,000- or 2,000-acre burn) to patrol the entire perimeter of the burn area and put out any fires that are outside the firelines. These men should be trained while the cleared firelines are being backfired, so that they will know what to expect from sagebrush fires and how to put out escape fires.

Start the fire late enough in the day so that if it does escape, little time will remain before temperatures drop, humidities rise, the wind goes down or reverses direction, and fires burn less briskly. The shorter the time in which the fire can burn rapidly, if it does escape, the less will be the damage to adjacent property before it is brought under control. On the upper Snake River plains fires set at 2:30 to 3 p. m., Mountain Standard Time, will have time to burn rapidly over 1,000 to 2,000 acres of range before burning conditions change.

The procedure in setting the fire varies with wind condition and direction. One system for use on a square tract similar to that shown in figure 17, to be burned under a southwest wind, is to have the fire set by two men. Both start at the southwest corner, and one goes north along the west side while the other goes east along the south side. It is important to set fires so that a solid wall of fire will sweep across the area. Setting a number of individual fires tends to produce an undesirably patchy burn. For this reason, the men setting the fires should move along rapidly, setting a continuous line of fire. At least one man should accompany each man setting fires to assist whenever possible and to prevent fires from crossing the single line to the windward.

The remainder of the crew should patrol the double line on the north and east sides to prevent fires from jumping across to the outside. Escape fires will seldom result from flaming pieces of brush or sparks flying through the air and over the fireline, but are more likely to arise from glowing embers blown along the ground. It is advisable to split the crew up into groups of three men, each group to patrol a sector of the line near the point at which the fire will strike. At the moment the fire hits the backfire area, those on patrol duty will need to watch carefully for fires in the outside unburned area. As soon as the fire within the burned area has died down at one point, the patrol at that sector can move on to another sector, leaving one of their group to guard the line.

Local fire wardens or employees of the Forest Service or Bureau of Land Management are well trained in matters pertaining to the control of fires. Their advice in preparing firelines, in burning the area, and in control of the fire will be very helpful in preventing escape of fire used in burning. The value of assistance by someone experienced in the performance of sagebrush fires and method of control cannot be overemphasized. Not only is experience beneficial in the actual burning operation, but also in the selection of areas to be burned.

Adequate precautions must be taken to insure safety of the men employed on sagebrush burning. Sagebrush fires travel rapidly in the dense cover and there is constant danger of personal injury if the men are not well organized and instructed. Crews should be given well-trained, responsible leaders who will know what to do in case of emergency. No individual should be permitted inside the control lines on the area being burned while burning is in progress.

Put out all fire before leaving the area, to insure the safety of adjacent property. As long as a fire is burning, there is always a chance that it can get outside control lines.

Cooperation in burning is desirable.—Necessary personnel may be difficult to get, as may be additional pasturage or hay to use during the time that burned areas are being given the needed protection. Large livestock operators, livestock associations, and Federal, State, or local agencies may have sufficient personnel, equipment, and rangeland to use planned burning satisfactorily. But the small operator may have to cooperate with other small operators in using planned burning.

Management After Burning

Management essential to favor the perennial grasses and weeds demands:

1. Protection of burned areas from trailing by livestock during the first fall at least.
2. Protection of burned areas from grazing for 1 full year.
3. Light grazing the second year, and thereafter no heavier than the range can support permanently.
4. The same grazing management for burned and reseeded areas as for areas not in need of reseeding.
5. For areas with more than half the understory in cheatgrass, special protection against recurrent accidental fires.
6. For accidentally burned areas, at least as good management after burning as that demanded for the best results from planned burning.

Grazing practice following burning is the most important single factor determining whether burning turns out well or badly. Even accidental

burns may produce good results on areas where conditions are otherwise favorable to burning if grazing is properly managed afterward. On the other hand, all the care taken to avoid burning at the wrong place and season and to control the fire may go for naught if improper grazing practices follow burning.

Protect perennial grasses and weeds.—They are the most valuable plants for spring-fall grazing use and the ones that good grazing management of these ranges aims to maintain or increase. They are more palatable and furnish a more consistent supply of forage than annuals—forage that is especially valuable during both the spring and fall seasons. They are much less flammable than cheatgrass. Furthermore, they provide the best type of cover for protecting the soil against wind and water erosion. They will generally increase relative to annuals if protected against trampling, if not grazed before they become well established, and if grazed moderately thereafter. If not so protected, they cannot well compete with the less nourishing and less palatable annuals.

Protect burned areas from trailing.—Trailing livestock across the burned area the first fall stirs up the unprotected dry soil and speeds wind or water erosion. The trailing livestock bring in sagebrush seed, primarily in their fleece or hair, and scatter it over the burned areas. The young sagebrush seedlings that come up early the first spring will be firmly established before the perennial grasses and weeds recover sufficiently to prevent it. Thus, trailing may alone be responsible for the reinvasion of sagebrush. If livestock must be moved across the burned area the first spring, this can be done with least damage to the plants and soil by moving the animals slowly and keeping them well spread out.

Do not graze for 1 full year after burning.—The amount of forage obtainable the first year is small and can be grazed only at the cost of serious damage to soil and desirable perennial plants. Any attempt to graze the scattered growth of perennial species and cheatgrass that occasionally comes in on the newly burned area after early fall rains will have the same effects as trailing—loss of soil and return of sagebrush, in addition to marked injury to the perennials that made regrowth.

As has been pointed out, the appearance of an abundance of green growth in the spring is deceptive. The reduced vigor of nearly all species is lost sight of because all the grasses and weeds on the area are exposed to full view at one time. Actually, the desirable plants have been weakened, some of them seriously (fig. 15). Grazing at this time is certain to utilize the more palatable species most heavily and further lower them in vigor or kill them out. In this weakened condition many of the perennial grasses and weeds are prevented from increasing in size or abundance, and the plant cover is kept so open that sagebrush can successfully return. Furthermore, grazing the open plant cover will stir up the inadequately protected soil and speed up wind and water erosion.

Graze lightly the second year and moderately thereafter.—It has been seen that at the end of the first year most of the plants are still suffering somewhat from the effects of burning. But in the second fall after burning the perennial species have matured and light grazing will not damage them. It may, in fact, help to plant any seed produced by perennial species. Anything more than light use must be avoided, however, especially if the grass stand is light.

Grazing should continue to be light through the second spring, even though there is often a marked increase in forage. This is normally a

period of heavy seed production by all perennials, the first since burning, and offers opportunity for the more desirable and palatable species to increase in numbers.

Rate of grazing on the burned area during the second year and thereafter should be based on the abundance of perennial grasses and weeds and recovery made by them. In general, the same number of animals carried under conservative grazing the fall and spring before the burn can be accommodated in these seasons in the second year after burning. This rule will hold only if the perennial grasses and weeds have made satisfactory progress since burning and have suffered no drought. Beginning the third year after burning, the number of animals can be increased if the improvement in the perennial grass and weed cover justifies an increase. Thereafter grazing should be adjusted to what the range can support on a permanent basis.

Light grazing is especially important where cheatgrass forms a preponderance of the cover. Any effort to utilize cheatgrass fully will result in overgrazing the perennial grasses and weeds, which are at all times much more palatable than cheatgrass.

Other practices that promote good grazing management.—These include good distribution of livestock, proper season of use, open herding, proper location of salt grounds, and rotation grazing management. These and all other practices that further good range use and thus assure maintenance of benefits derived from burning should be employed to help in maintaining increased grazing capacity and usability of the range.

Adapt grazing to rotation burning.—In rotation burning, each newly burned portion must have protection against grazing for 1 year. In an operation in which the range was fully stocked before burning, this necessitates leasing or purchasing additional range, providing other feed equivalent to the forage burned each year for the period of the rotation, or reducing the number of livestock. Only where there was actual understocking before burning should the unburned portions be made to carry some or all of the livestock from the freshly burned portion. In that case, however, the increases in stocking must be gaged strictly by the grazing capacity of the unburned range.

A sample grazing schedule for an area similar to that shown in figure 17 is presented in table 1 for the years 1953–57. In this case, it is assumed that additional pasturage or feed is available for the first part of the spring season and the end of the fall season, so that, when burning starts and for 1 year after it is completed, the full number of animals graze the area for only three-quarters of the customary spring and fall seasons. In the spring, grazing use is so rotated that each unit is grazed during the same period of the spring season only once every 4 years. Such rotation is unnecessary in the fall, inasmuch as the plants are then mature. The unit to be burned each year should be grazed first in the spring of that year, so as to take advantage of the forage produced and permit growth after grazing to accumulate as much herbaceous fuel as possible.

By the fall of 1956 the entire area has been burned over and in the fall of 1957 grazing is resumed for the full season. No subsequent burning will be necessary. If the progress made by perennial species justifies it, the period of grazing on Unit A may be lengthened beginning with the fall season of 1955, and that of Unit B beginning with the fall of 1956. If this can safely be done it may relieve somewhat the need for pasturage or feed in 1955–57.

TABLE 1.—*Spring and fall grazing schedule for rotation*[1] *burning, allowing the year of protection needed for each unit after burning*

Year and season	Unit A—burned 1953	Unit B—burned 1954	Unit C—burned 1955	Unit D—burned 1956
1953:				
Spring	Period 1	Period 2	Period 3	Period 4.
Fall		¾ season	¾ season	¾ season.
1954:				
Spring		Period 2	Period 3	Period 4.
Fall	¾ season		¾ season	¾ season.
1955:				
Spring	Period 4		Period 2	Period 3.
Fall	¾ season	¾ season		¾ season.
1956:				
Spring	Period 3	Period 4		Period 2.
Fall	¾ season	¾ season	¾ season	
1957:				
Spring	Period 2	Period 3	Period 4	
Fall	Full season	Full season	Full season	Full season.

[1] Units A, B, C, and D are equal in grazing capacity; as indicated in the headings, one is burned each year from 1953 to 1956. Spring grazing season is divided into four 15-day periods—April 24–May 9, May 9–May 24, May 24–June 8, and June 8–June 23; fall grazing runs from October 1 to November 15 during the burning operation, but thereafter for the full season, to December 1. In the spring of 1953 and the fall of 1957, and of course, thereafter, the entire range is grazed for the full season; at all other times on the schedule the area is grazed for three-quarters of the season starting 15 days later in the spring and ending 15 days earlier in the fall.

Rotation burning and subsequent rotation grazing can be used more readily on sheep ranges, because sheep movements from unit to unit can be easily controlled by the herder. With cattle this system is somewhat more difficult, requiring fences to prevent cattle from congregating on the newly burned area and the older burns, and to facilitate rotation between the units. Electric fences, where practicable, would provide a low-cost method for managing the distribution of cattle.

It is particularly hazardous to graze a new stand of grass seedlings.—Young and weak-rooted grass seedlings are easily killed out by trampling or pulled out by grazing animals. They are, therefore, critically in need of complete protection from grazing or trailing the first year after burning and seeding, to permit them to become firmly established. Good stands of grass have been obtained on reseeded areas that were grazed lightly or conservatively during the first growing season, but much more rapid and vigorous growth will be made if the areas are protected. In the second fall any attempt to graze the area fully will cause far more damage than the negligible quantity of forage furnished by the newly seeded stand will offset. Light grazing during the second year and the application of other principles of good grazing management thereafter are necessary to increase and maintain the stand of reseeded perennials.

Cheatgrass areas must have special protection against recurrent accidental fires.—The removal of sagebrush from dense cheatgrass areas and the temporary increase of cheatgrass greatly increases the flammability of the cover for a large part of the summer. Special precautions are needed to prevent accidental midsummer fires and subsequent loss of forage, injury to the perennials, and further increase of cheatgrass. The danger can be minimized by the construction of single cleared firelines along railroads, highways, or well-traveled roads, where accidental fires are most likely to start. Spread of fire can be minimized by clearing lines to divide the area into blocks; and if these are cleared with a grader, removing the cheatgrass and the seed on the ground surface, they may be successfully reseeded to crested wheatgrass or other perennial grasses or to yellow sweetclover. The perennials,

in the absence of competition by cheatgrass, are likely soon to form permanent belts of relatively nonflammable plant cover, which should give permanent protection and at the same time increase grazing capacity.

Give accidental burns protection from grazing.—The above guides for grazing management after burning are for areas where all requirements regarding where and when to burn have been given thorough consideration before burning. Each year there are, however, thousands of acres of sagebrush range accidentally burned. On these, no grazing or trailing the first spring, light grazing the second year, and the application of other principles of good grazing management should be of great value in avoiding further loss of the forage that survives. In every instance the practices outlined as a part of planned burning will apply. If the accidental fire happens to come in later summer or early fall and is confined to a level or rolling area that has a good understory of perennial grasses, the application of proper grazing practices will bring back the range at least to its former grazing capacity and is likely to produce the same good results obtained by planned burning.

Additional care is often needed where accidental fires occur early in the summer, where they cover cheatgrass areas, steep slopes, readily erosible soils, areas with too sparse stands of grass, or with Idaho fescue or other nonresistant species as a major part of the understory. To prevent serious damage in such cases, special treatment is essential, such as longer periods of protection from grazing or light or deferred grazing.

COSTS OF RANGE IMPROVEMENT BY PLANNED BURNING

Total costs of range improvement by planned burning of sagebrush range are made up of the costs of constructing the firelines, of actually burning the area (including the wages of crews used for patrolling line), of grazing protection where additional range must be leased or additional hay purchased, and of reseeding where that is necessary following sagebrush removal. Costs vary widely, depending upon the size and shape of area to be burned, the presence of roads or streams which can be taken advantage of as firebreaks, and the length of new fireline needed.

The major cost is that of adequate firelines. The total cost of a double line ranges from $120 to $160 per mile, varying with conditions and type of equipment necessary: Clearing the lines with heavy equipment costs between $30 and $70 per mile, and backfiring the uncleared strip between the two lines costs approximately $90 per mile. Single cleared lines (one swath of the grader or patrol blade) cost between $10 and $25 per mile.

The total cost of burning, exclusive of reseeding and grazing protection, computed on the basis of a rectangular 1,000-acre area, 1½ miles by 1 mile in size, with an adequate perennial grass and weed understory varies from 44 to 57 cents per acre, assuming that two sides must be protected by double, backfired lines and two sides by single cleared lines:

Firelines constructed with road patrol:	
Rental of road patrol (10 hours @ $7.05)	$70.50
Patrol operator (10 hours @ $2.00)	20.00
Total	$90.50

Firelines constructed with tractor-grader:	
Rental of D–7 caterpillar tractor (16 hours @ $7.85)	$125.60
Rental of heavy grader (16 hours @ $2.25)	36.00
Equipment operator (32 hours @ $2.00)	64.00
Total	$225.60
Costs in addition to those for equipment and operator:	
Backfiring the double line (16 man-days @ $12.00)	$192.00
Burning the area (8 man-days @ $12.00)	96.00
Miscellaneous—burners, kerosene, transportation	60.00
Total	$348.00
Total cost of burning where patrol can be used	$438.50
Cost per acre	.44
Total cost of burning where "cat" and grader must be used	$573.60
Cost per acre	.57

If tracts of four sections (2,560 acres), forming a square area 2 miles on a side, are burned at one time, costs are reduced approximately 15 cents per acre. The lower cost per acre of burning the larger area results from the fact that 150 percent more area is burned but only 60 percent more fireline is required than for the 1,000-acre tract.

To the costs listed above must be added at least 20 cents per acre for loss in grazing privileges; and where reseeding is necessary following burning, from $3 to $5 per acre. On cattle ranges, the cost of temporary fences needed to control the cattle should be added.

LIST OF ACCEPTED COMMON NAMES AND SCIENTIFIC NAMES OF SPECIES MENTIONED

Grasses and Grasslike Plants

Bluegrass, Nevada	*Poa nevadensis*
Bluegrass, Sandberg	*P. secunda*
Brome, cheatgrass ("cheatgrass," "bronco-grass," "downy brome," "downy chess").	*Bromus tectorum*
Fescue, Idaho	*Festuca idahoensis*
Junegrass, prairie	*Koeleria cristata*
Needle-and-thread	*Stipa comata*
Needlegrass, subalpine	*S. columbiana*
Reedgrass, plains	*Calamagrostis montanensis*
Ricegrass, Indian	*Oryzopsis hymenoides*
Sedge, Douglas	*Carex douglasii*
Sedge, threadleaf	*C. filifolia*
Wheatgrass, bluebunch	*Agropyron spicatum*
Wheatgrass, crested	*A. cristatum*
Wheatgrass, thickspike	*A. dasystachyum*

Weeds

Arnica, orange	*Arnica fulgens*
Astragalus	*Astragalus salinus; A. stenophyllus*
Balsamroot, arrowleaf	*Balsamorhiza sagittata*
Comandra, common	*Comandra umbellata*
Deathcamas, foothill	*Zigadenus paniculatus*
Eriogonum, mat	*Eriogonum caespitosum*
Eriogonum, Wyeth	*E. heracleoides*
Fleabane, hairy	*Erigeron concinnus*
Fleabane, purpledaisy	*E. corymbosus*

Weeds—Continued

Geranium, sticky	*Geranium viscosissimum*
Globemallow, Munro	*Sphaeralcea munroana*
Groundsel, lambstongue	*Senecio integerrimus*
Hawksbeard, tapertip	*Crepis acuminata*
Lupine, tailcup	*Lupinus caudatus*
Lupine, velvet	*L. leucophyllus*
Onion, wild	*Allium* spp.
Paintedcup, northwestern ("Indian paintbrush").	*Castilleja angustifolia*
Plainsmustard, flaxleaf	*Sisymbrium linifolium*
Penstemon, matroot	*Penstemon radicosus*
Phlox, hoary	*Phlox canescens*
Phlox, longleaf	*P. longifolia*
Pussytoes, littleleaf	*Antennaria microphylla*
Pussytoes, low	*A. dimorpha*
Sandwort, Uinta	*Arenaria uintahensis*
Yarrow, western	*Achillea lanulosa*

Shrubs

Bitterbrush, antelope	*Purshia tridentata*
Gilia, granite	*Gilia pungens*
Horsebrush, spineless gray	*Tetradymia canescens inermis*
Rabbitbrush, downy	*Chrysothamnus puberulus*
Sagebrush, big	*Artemisia tridentata*
Sagebrush, threetip	*A. tripartita*
Serviceberry, Saskatoon	*Amelanchier alnifolia*
Snakeweed, broom	*Gutierrezia sarothrae*
Snowberry, mountain	*Symphoricarpos oreophilus*

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